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A STUDY ON THE FUSION REACTION $^{139}La + ^{12}C$ AT 50 MeV/u WITH THE VUU EQUATION

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Résumé Récemment, Bowman et collaborateurs ont trouvé que dans la réaction $^{139}La + ^{12}C$ à 50 MeV/A un résidu de fusion est formé. Nous simulons cette réaction en résolvant l'équation VUU et nous trouvons effectivement que dans le cas d'une collision centrale le système fusionne et s'équilibre après 90 fm/c.

Abstract Recently Bowman et al. found that in the reaction $^{139}La + ^{12}C$ at 50 MeV/u a compound nucleus is formed. We simulate this reaction with a numerical solution of the VUU equation and indeed find that for a central collision the system fuses and equilibrates after 90 fm/c.

In a recent experiment Bowman et al. [1] found the surprising feature that at an energy as high as 50 MeV/u the system $^{129}La + ^{12}C$ apparently forms a hot compound nucleus which sequentially undergoes fission. In this work we perform a theoretical study on this reaction using the now available numerical solution of the Vlasov Uehling Uhlenbeck equation [2,3]. For the mean field we use [4]

$$U(\rho) = \frac{3}{4} t_0 \rho + \frac{13}{96} t_3 \rho^{7/6} \qquad t_0 = -3273.6 \qquad t_3 = 21290.0 \tag{1}$$

and for the effective cross section entering the collision integral

$$\left.\frac{d\sigma}{dE}\right)_{eff} = \left.\frac{d\sigma}{dE}\right)_{free} Y(\rho) \tag{2}$$

with

$$Y(\rho) = \frac{1}{2} + \frac{1}{2}\left\{1 + \exp\left[\frac{\rho - 0.12}{0.02}\right]\right\}^{-1} \tag{3}$$

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where the attenuation factor Y was adjusted to the G-matrix calculation by Lejeune et al.[5]. Using these ingredients we show on Fig. 1 the evolution of the reaction $^{139}La + ^{12}C$ at 50 MeV/u for zero impact parameter. We see that the ^{12}C has been "swallowed" by the ^{139}La after 40 fm/c accompanied by an increase of the density up to 1.3 ρ_o. From 40 fm/c to 70 fm/c follows a decompression phase undershooting the saturation density by $\sim$ 10%. In parallel with this decompression phase goes a forward-backward emission of pre-equilibrium particles (see below). For later times a monopole vibration establishes with particle emission which has become isotropic at 90 fm/c.

In Fig. 2 we show the time evolution of the pressure tensor which is averaged over the directions perpendicular to the beam. We thus display on the graph the two dimensional function

$$\eta(z,t) = \frac{P_{xx}(z,t) + P_{yy}(z,t)}{2\,P_{zz}(z,t)} \tag{4}$$

We see that the value η = 1 and thus local equilibrium is reached after 80 fm/c. We therefore fully confirm the findings of ref [1] in the sense that an equilibrated compound nucleus is formed in the reaction $^{139}La + ^{12}C$ for 50 MeV/u.

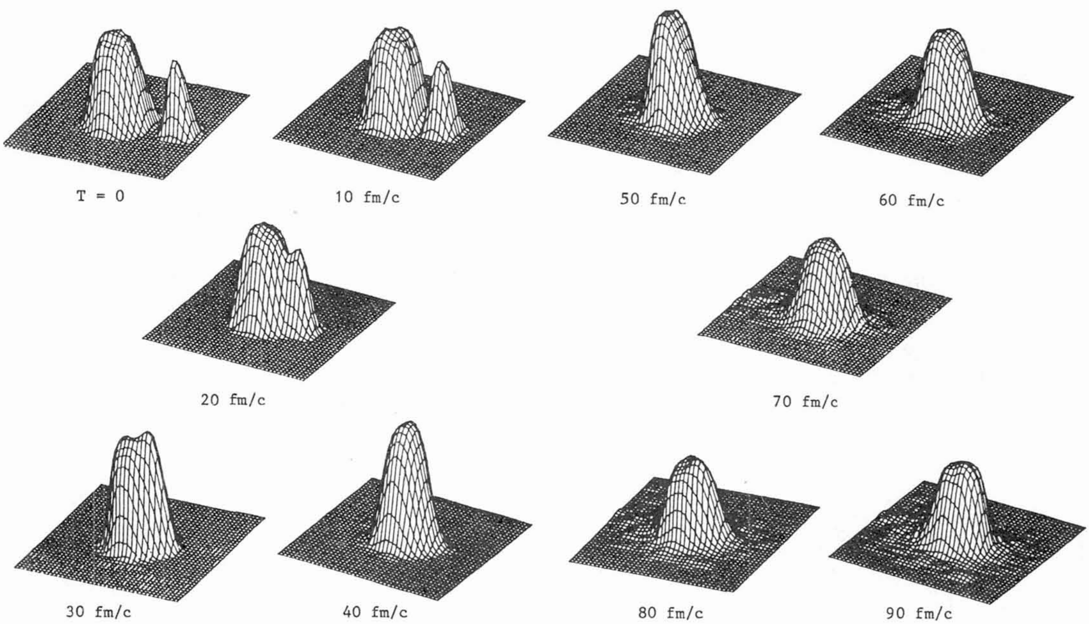

Fig. 1 Total density of colliding nuclei averaged in the Y direction at different time steps.

Further studies using different impact parameters and still higher energies are underway. At the moment we stopped our calculations at 90fm/c; it would be an interesting question to see whether these calculations allow at much longer times for fission.

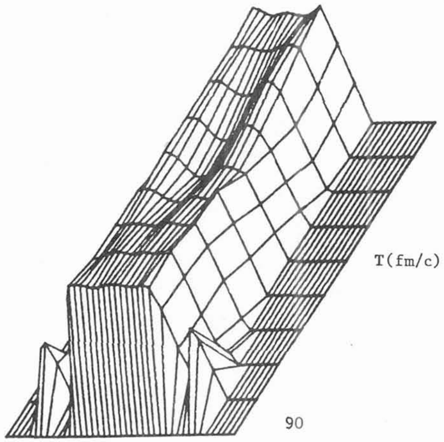

Fig. 2 Representation of (Z,t) function (see the text)

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